DOCUMENT RESUME

ED 437 404 TM 030 556

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TITLE	Schema Modification and Enhancement as Predictors of Interest: A Test of the Knowledge-schema Theory of Cognitive Interest.
PUB DATE	1999-04-00
NOTE	46p.; Paper presented at the Annual Meeting of the American Educational Research Association (Montreal, Quebec, Canada, April 19-23, 1999).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	*Cognitive Processes; Educational Theories; Higher Education; Prediction; *Student Interests; *Undergraduate Students
IDENTIFIERS	*Schema Theory

ABSTRACT

A general cognitive theory of interest is offered to allow for predicting the degree to which any informational environment is perceived as interesting. The theory is assessed in a study that tested predictions of a knowledge-schema theory of cognitive interest. Three classes of hypotheses regarding the cognitive causes of interest are identified (complexity, novelty, and unexpectedness hypotheses). A domain-and-modality-general theory, referred to as the knowledge-schema theory of cognitive interest (KST), captures the underlying regularities of these specific hypotheses by positing learning via schematic enhancement and schematic modification as causes of interest. The predictions of the KST were tested with 63 undergraduates. It was expected that those who learned more from a target passage, as measured by improvement on a memory test, would rate the passage as more interesting than those who learned less. Participants demonstrated greater learning for concepts in the target passage that were more related to their knowledge-schema than for concepts less related to this schema. Participants also generally judged the paragraphs of the target passage that had led to greater schema enhancement as more interesting than the paragraphs that induced less schema enhancement. In addition, the amount of learning induced by the target passage did predict the degree to which a participant judged the passage as interesting. Findings provide support for the KST regarding the causes of cognitive interest. Three appendixes contain sample test questions for domain knowledge and target passages. (Contains 54 references.) (SLD)

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Schema Modification and Enhancement as Predictors of Interest:

A Test of the Knowledge-schema Theory of Cognitive Interest

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Paper presented at the 1999 Annual Meeting of the American Educational Research Association, Montreal.

In the early part of this century, educational researchers and philosophers stressed the importance of piquing and maintaining the interest of students in the classroom. Most of these early discussions of interest (e.g., Arnold, 1910; Bartlett, 1932; De Garmo, 1902; Dewey, 1913; Thorndike, 1935) focused on the importance of gearing instruction around topics in which students were interested, that is, students' individual interests. Over the past three decades, however, many researchers have turned their attention to what Kintsch (1980) refers to as cognitive interest: interest driven by the relation between information in an environment (e.g., verbal information, perceptual stimuli) and a person's state of knowledge.

It has been well established that increasing interest for information has a positive impact on numerous indicators of learning. A large body of experimental evidence shows that increased interest leads to increases in comprehension, depth-of-processing, transfer of learning, and recall and recognition for information (see Alexander, Kulikowich, & Jetton, 1994, and Hidi, 1990, for reviews). The effort to spell out cognitive factors that contribute to interest has been somewhat less successful. As Krapp, Hidi, and Renninger (1992) point out, "[T] he research to date has focused primarily on interest as an independent variable. As such, the variables studied, the questions posed, and the methodologies employed have been driven by the need to establish how interest affects achievement, cognition, vocational choices, and so on, rather than questions related to the nature, determinants, and functions of interest per se" (p. 19). Several specific hypotheses regarding the causes of cognitive interest have been proposed and tested. Still, no general theory has been established that can predict degree of interest across a wide range of informational environments. Regarding past attempts to identify causes of interest for information, Wade, Buxton, and Kelly (in press) state that "most studies have been piecemeal, examining a number of predetermined and isolated variables." The purpose of the current paper

is to offer and assess a general, cognitive theory of interest that will allow for predicting the degree to which any informational environment is perceived as interesting.

I will begin this article by briefly describing three distinct classes of hypotheses regarding the cognitive causes of interest (complexity, novelty, and unexpectedness hypotheses) and pointing to the regularities that these classes of hypotheses all share. I will then show how a domain- and modality-general theory, which will be referred to as the knowledge-schema theory of cognitive interest (KST), captures the underlying regularities of these specific hypotheses by positing learning via schematic enhancement and schematic modification as causes of interest. Finally, an experiment that tests predictions of the KST will be described and discussed.

Existing hypotheses of the causes of cognitive interest

Complexity. In his work on interest for perceptual stimuli, Berlyne (1960, 1971, 1974) found that variations of complexity in stimuli had differential effects on perceived interest. Specifically, when the amounts of complexity were low or high, participants showed little interest, but when complexity was at an intermediate level, interest in the stimuli was increased. Berlyne explained these findings with his arousal-jag hypothesis, claiming that interest was a result of an initial period of arousal due to some disorientation, followed by an assimilation of the information. Thus, when arousal is not induced (when complexity is low) or when the information cannot be assimilated (when complexity is high), interest is low; when both arousal and eventual assimilation are possible (when complexity is intermediate), then interest should occur. These predictions were supported by the work of Day (1965, 1967, 1968), who demonstrated that interest judgments of visual stimuli followed an inverted-U pattern as a function of complexity.

Other work on the effects of complexity on interest has established that people prefer tasks that are of intermediate complexity (e.g., Boggiano, Ruble, & Pittman, 1982; Boykin, 1977; Csikszentmihalyi, 1975, 1990; Danner & Lonky, 1981; McMullin & Steffen, 1982; Shapira, 1976). For example, Boykin (1977) studied the relation between complexity and interest for an anagram-solving task, with complexity manipulated by varying the number of letters within the anagram. As did Day (1965, 1967, 1968), Boykin observed an inverted-U relationship between complexity and interest. An individual-participants analysis showed that participants judged the task most interesting at their highest level of competence, that is, at the most complex level at which they solved the anagrams proficiently. This phenomenon, which Boykin refers to as the preference-processing hypothesis, indicates that interest is highest for tasks that are challenging yet solvable.

Novelty. Berlyne (1960, 1971, 1974) applied his arousal-jag hypothesis to explain the relation between the novelty of a perceptual stimulus and interest for that stimulus. Analogous to his predictions of complexity and interest, Berlyne claimed that interest would be highest for stimuli at an intermediate amount of novelty, while interest would be low when there is either a low or high amount of novelty.

Kintsch's (1980) prior knowledge hypothesis also predicts an inverted-U relation between novelty and interest. This hypothesis holds that interest in a textual passage will be low when the reader is either completely unknowledgeable or completely knowledgeable about the content of the material, but will be high when the reader possesses some intermediate amount of knowledge about the content.

Like Kintsch (1980), Teigen (1985a, 1985b, 1987) recognized that the novelty of information, and subsequent interest, occurred as an interaction between one's prior knowledge and the

informational environment. Teigen's (1987) novelty-familiarity interaction hypothesis holds that a combination of novelty and familiarity between a person's knowledge and the incoming information determines interest. Teigen's hypothesis posits that interest is engendered when incoming information is informative. According to Teigen, this occurs when one of these elements, either the person's knowledge structures or the incoming information, is novel and the other familiar. Further, Teigen claims that interest will be low in a situation when incoming information is not informative, which occurs when both elements are novel or both are familiar. In other words, incoming information is informative, and thus interesting, when one encounters new information about something of which one is already familiar, or when one encounters a familiar type of information in a domain in which one is not familiar with (e.g., an analogy). According to Teigen's hypothesis, information is not informative (and thus not interesting) when one is told something familiar about something one is familiar with (i.e., something one already knows), or something new about something with which one is not familiar.

Unexpectedness. A number of researchers have studied the effect of unexpected information on interest. Schank (1979) and Mandler (1982) proposed that unexpected events, such as surprises or anomalies, are inherently interesting, since this information disrupts the normal unfolding of a script, or schema. Kintsch (1980), however, stated that surprise or unexpectedness alone does not drive interest, but that there must also be a potential for resolution, or postdictability, present for interest to occur. That is, according to Kintsch's postdictability hypothesis, it is not the disruption of the schema that leads to interest, but rather it is the potential integration, or assimilation of the unexpected information through some resolution, that affects interest. The postdictability hypothesis thus predicts that unexpectedness will lead to high interest only when it is at an intermediate amount, where some disruption occurs but

postdictability is obtainable. For situations of low unexpectedness, when no disruption occurs, and high unexpectedness, when disruption occurs but postdictability is not attainable, this hypothesis predicts that interest in the information will be low.

Two experiments by Iran-Nejad (1987) provided evidence that postdictability was indeed necessary for making unexpected information interesting. Iran-Nejad had participants read stories that varied in both degree of the surprise of their ending and their degree of resolution. His findings support Kintsch's (1980) hypothesis: only in the resolved condition, where the surprise endings of the stories were sufficiently resolved to allow for postdiction, were the high-surprise stories rated as significantly more interesting than the low-surprise stories.

Frick (1992) also posits that unexpectedness is not sufficient to cause interest, but must be paired with the possibility of change in a belief. According to Frick's <u>changing beliefs hypothesis</u>, the degree of unexpectedness is not predictive of the amount of interest unless the unexpectedness causes one to change their beliefs or confidence in their beliefs. Frick (1992) tested his hypothesis by assigning participants to perform 25 trials of one of two tasks, either flipping a penny in the air or spinning a penny on a flat surface. Participants in each group expected their task to be unbiased, that is, that the probability of getting heads or tails are equal ($P = .50$) for both flipping and spinning. In fact, penny-spinning results in a greater probability of getting a tails result ($P = .80$) than a heads result ($P = .20$). Thus, Frick predicted that participants in the penny-spinning group, who would have to change their beliefs about the probability of getting a certain outcome, would report higher interest in the task than those in the penny-flipping group, whose expected probabilities would be consistent with the observed outcomes. His hypothesis was supported by his findings, in that the average interest in the penny-spinning group was significantly greater than that in the penny-flipping group.

A notable trend in participants' trial-by-trial report for the penny-spinning group lends further support for this hypothesis. Interest ratings rise steadily for this group, peaking at about thirteenth trial, after which interest ratings slowly decline. Verbal protocols indicate that until this point, participants maintained their belief in the equal probability of a heads or tail outcome. Their interest rose as the evidence became increasingly inconsistent with their belief. However, sometime around the thirteenth trial, participants changed their beliefs, in that they now expected a greater number of tails than heads, and thus further evidence, which was now consistent with their new belief, elicited less and less interest.

The knowledge-schema theory of interest

The preceding hypotheses regarding cognitive causes of interest exemplify the piecemeal approach to understanding interest noted by Wade, Buxton, and Kelly (in press). For the most part, these hypotheses explain causes of interest only within a particular class of informational properties (i.e., complexity, novelty, or unexpectedness), and only within particular modalities (e.g., perceptual stimuli, cognitive tasks). What is needed is a theory of cognitive interest that is both modality and domain-general, which can encompass prior findings across modality and classes, and make specific predictions about cognitive interest for many informational environments.

The theory that will be proposed and tested here is the knowledge-schema theory of cognitive interest (KST). This theory is based upon the assumption that interest for any informational environment varies directly with several key components of this information. These include usefulness and comprehensibility of information, its meaningfulness, and its ability to be processed and incorporated into a person's knowledge structures, or schemas. This incorporation can take two forms: 1) schema enhancement, or schema elaboration, which occurs when new

information fills in empty slots of a pre-existing schema, thus increasing one's knowledge while maintaining the basic schematic structure (i.e., assimilation of new information into a current schema), and 2) schema modification, or schema change, which occurs when new information leads to a radical restructuring of a pre-existing schema, increasing one's knowledge by changing the schematic structure (i.e., accommodation of a schema to fit new information). The KST therefore holds that when learning is produced by information in an environment through either schema enhancement or schema modification, that information will be perceived as interesting.

How the knowledge-schema theory accounts for previous findings. One of the strengths of the knowledge-schema theory is that it accounts for findings from the previous disparate research discussed above. The knowledge-schema theory, which holds that cognitive interest is driven by schema enhancement and schema modification, identifies the construct underlying these specific hypotheses and reframes the phenomenon of cognitive interest in more generalizable terms.

While findings of the effect of complexity on interest were not interpreted in terms of learning via the process of schema enhancement, the relation is quite apparent. When attending to information that is of low complexity (such that the information not challenging), little or no schematic enhancement should occur, as this information does not add meaningfully to a person's current knowledge. When encountering information that is too high in complexity (such that the information is too challenging), again little or no schematic enhancement should occur, as this information cannot be understood and processed in terms of a person's current knowledge. However, when information is at some intermediate level of complexity, schema enhancement is likely to occur, for this information is understandable in terms of one's current knowledge structures, but it provides something new and different that will meaningfully add to or change

this knowledge. Thus, the degree to which information leads to schema enhancement seem directly related to interest for that information.

Findings from work on novelty and interest also conform to the predictions of the knowledge-schema theory. Berlyne's (1960) and Kintsch's (1980) hypotheses of an inverted-U relation between novelty and interest map well onto a theory that proposes schematic enhancement as a predictor of interest. When a person is completely unknowledgeable, such that the incoming information is of high novelty, they have no existing schematic framework upon which to assimilate the incoming information, and thus schematic enhancement should be minimal. When a person is completely knowledgeable, such that the incoming information is of low novelty, the incoming information is redundant to their current knowledge, and again schematic enhancement should be minimal. However, when a person is moderately knowledgeable, such that the incoming information is of intermediate novelty, they have an existing, yet incomplete schematic framework upon which the incoming information can be easily assimilated, and thus will be able to optimally process and learn from the passage. Again, the degree of schema enhancement that is induced by an informational environment seems predictive of the resulting interest.

The knowledge-schema theory also accounts for predictions made by Teigen's (1987) novelty-familiarity interaction hypothesis. According to Teigen, interest is high when one encounters new information about something for which one is already familiar, or when one encounters a familiar type of information in a domain in which one is not familiar with. The KST also predicts interest will be high in these two contexts. In the first of these situations, absorption of the incoming information should elaborate upon one's knowledge, for in this situation a schema is already developed, and the information will, by its newness, enhance that schema. In the second of these situations, absorption of the incoming information should cause

schematic change, such that an existing schema will be modified in a manner that best represents the relation of this incoming information to previous knowledge to which it is familiar in type. Teigen also claims that interest will be low when one encounters familiar information about something one is familiar with or something new about something with which one is not familiar. The KST also predicts low interest in both of these scenarios. In the first of these situations, the information cannot be processed at all, so existing schemas cannot sufficiently allow the person to understand and thus process this information. In the second of these situations, there is no need for processing, as the information is redundant to knowledge already represented in the schema.

Findings from work on the relation between unexpectedness and interest are also accounted for by the knowledge-schema theory. Kintsch's (1980) postdictability hypothesis holds that it is the assimilation of unexpected information through some resolution that affects interest, such that unexpectedness will lead to high interest only when it is at an intermediate amount, where some disruption occurs but postdictability is obtainable. This hypothesis clearly maps onto the KST. Without postdiction, an unexpected event only disrupts a schema, but does not enhance or modify the schema; postdictability allows for the unexpected information to be eventually assimilated into the current knowledge structures, or to modify the pre-existing schema, and thus is necessary to increase interest.

The KST similarly accounts for Frick's (1992) claim that changing beliefs leads to interest. Consistent with Frick's hypothesis, the KST does not predict that mere unexpected information will be sufficient to increase interest; however, when the unexpected information leads to a modification of one's knowledge (i.e., changes a belief), interest should result. Thus, the KST also predicts Frick's findings: interest in the penny-spinning task rose as evidence inconsistent

with one's schemas increased, reached a peak when the schema was modified to incorporate this information, and then decreased as the incoming information was now redundant with their knowledge-structures, no longer eliciting significant schema elaboration or change.

Previous tests of the knowledge-schema theory of cognitive interest. Previous experiments (Yarlas, 1999) have examined the basic claims of the knowledge-schema theory, schema modification and that schema enhancement are causes of interest. In two experiments, both schema modification and schema enhancement were manipulated to examine their effects on interest for information using Frick's (1992) flipping/spinning penny scenario. Unlike in Frick's experiment, however, participants in the experiments testing the claims of the KST learned about the probability of these outcomes from reading a passage, rather than by actually flipping or spinning pennies.

Schema modification was manipulated by having participants read a passage that contained information about either an expected or an unexpected outcome. In the expected outcome condition, participants read that flipping a coin in the air yields that a 50% probability of a "heads" outcome, which should be consistent with their prior belief and should produce no schema modification. In the unexpected outcome condition, participants read that spinning a coin on a flat surface yields a 20% probability of a "heads" outcome, which should be inconsistent with their prior belief (that it is a 50% probability), producing schema modification.

Schema enhancement was manipulated by giving participants either explanatory or descriptive information to explain these outcomes. Participants in the explanatory condition received mechanistic information about the outcome, which explains how the physical features of a U. S. penny lead to a 'heads' outcome 50% of the time when a penny is flipped, or a 'heads' outcome 20% of the time when a penny is spun. Participants in the descriptive condition received

frequency information about the outcome, which describes a number of trials of penny flipping that led to a 'heads' outcome half of the time, or trials in which spun penny led to a 'heads' outcome 20% of the time.

The KST predicts that interest will be higher for passages containing unexpected outcomes than for those containing expected outcomes, since the former passages induce greater schema modification, and that interest will be higher for passages containing explanatory information than for those containing descriptive information, since the former passages induce greater schema enhancement. In both experiments, the data strongly supported both of these predictions. In addition, in both experiments a moderately strong correlation between degree of learning from the passage and interest ratings were evidenced, and covariance matrix modeling techniques indicated that the model in which degree of learning from the passage predicted interest for the passage was the only among several alternatives that adequately fit the data.

While these experiments provided preliminary support for the knowledge-schema theory as a predictive model of interest, there were a number of limitations that make further research necessary to more solidly establish the claims of the KST. One limitation is that learning was measured from self-reports, rather than from a demonstration of actual learning. Research has shown (e.g., Glenberg, Wilkinson, & Epstein, 1982) that what one thinks they have learned does not directly correspond to what one has actually learned; thus, perceived learning is not an optimal indicator of true learning. To increase the validity of learning measures, the current experiment uses demonstration of learning rather than self-reports.

A second limitation is that the passages used in these experiments were of low conceptual complexity, only dealing with a single, simple concept, the outcome of either penny flipping or penny spinning. Passages used in real-world contexts (e.g., a classroom setting) are generally

more conceptually complex. The amount of learning from these passages, then, is quite relative; the degree of schema modification or enhancement induced by the passages was low relative to the amounts induced by passages dealing with more complex information. The current experiment incorporates a longer, conceptually rich passage that more closely approximates the informational environments regularly encountered in real-world settings.

The previous studies of the KST focused only on the environmental aspect of the knowledge/environment interaction inherent in the assumptions of the knowledge-schema theory. These experiments assumed that all participants possessed the same pre-experimental schema regarding the outcomes of penny flips and penny spins (i.e., each leading to a 'heads' outcome 50% of the time), and expected differences in interest ratings as a function of giving them different passages. This brings up a third limitation of these studies: using different passages across participants leads to a potential confound, in that interest for the passages might have varied due to factors other than the ones manipulated. For example, it might be that participants found the unexpected outcome (penny spinning) passages more interesting than the expected outcome passages (penny flipping) because of their greater novelty; flipping a coin is a more familiar activity than spinning a coin, and the relative novelty of the latter event might have made its discussion more interesting to participants independent of the expectedness of the outcome. Because of this confound, the current experiment examines participants' interest ratings for the same target passage, thus focusing on the knowledge aspect of the knowledge/environment interaction by looking at how differences in prior knowledge affect interest for the same informational environment.

Current Research

To further specify the knowledge-schema theory as a predictive model of cognitive interest, a closer examination is needed of the relation between prior knowledge and incoming information, and how this relation affects interest for the information. Given that information more conceptually related to a schema is more likely to induce elaboration than information less related to the schema, the KST predicts that interest will be higher for the former information than the latter information. The purpose of the current experiment is to test this hypothesis. Three critical predictions are tested in this experiment: 1) that concepts more closely related to a knowledge-schema would lead to a higher degree of schema enhancement than concepts less related to a schema, 2) that information that leads to a greater amount of schema enhancement will be considered more interesting than information that leads to a lesser amount of schema enhancement, and 3) that the amount of learning induced by information positively affects interest.

Experiment

In addition to the improvement the current experiment makes upon the three critical limitations of earlier experiments discussed above, this experiment also introduces methodological improvements over prior research on cognitive interest by measuring and controlling for extraneous variables that might be expected to affect interest judgments for a text. One such variable is individual interest for the domain that the text concerns, in this case physics, and more specifically quantum physics. Remarkably, almost all studies of cognitive interest have failed to control for individual interest in the topic of their informational stimuli. In response to this problem (specifically for studies examining interest for scientific textual passages), Alexander and Jetton (1996) ask "[W]ere these ratings markers of students' passing interest in the content (situational interest) or did they signify a more deep-seated involvement in these

scientific fields (individual interest)?" (p. 103). Previous studies lend us no reason to reject the latter alternative: individual interest for a topic most surely affects interest ratings for information concerning that topic. To assess the predictiveness of other factors on cognitive interest, it is necessary to parse out the variance in interest judgments due to individual interest.

The current study will also control for another factor shown in previous research to affect learning and interest for physics, namely gender. Numerous studies have found that males have a greater interest in physics and science in general (Harty, Samuel, & Beal, 1986; Pell, 1985; Tamir & Gardner, 1989; Yarlas, 1998) and greater knowledge of physics (Smail & Kelly, 1984; Yarlas, 1998) than females. Because of these findings, the current study includes gender as a covariate.

The experimental manipulation in this experiment is a property directly affecting the magnitude of schema elaboration: the conceptual relatedness between incoming information and one's prior knowledge. It is expected that incoming information that is more conceptually related to a pre-existing schema is more likely to induce elaboration than information less related to the schema. The knowledge-schema theory of cognitive interest, then, predicts that the former type of information would be considered more interesting than the latter type of information.

This experiment examines two hypotheses of the knowledge-schema theory of cognitive interest. The first hypothesis is that higher degrees of conceptual relatedness between a pre-existing schema and incoming information will lead to increased interest for this information than for information less related to the schema, since the former information is expected to lead to a greater degree of schema elaboration than the latter. The second hypothesis is that interest for information will increase as a function of the amount of learning induced by that information.

To test the first hypothesis, conceptual relatedness of the target information to participants' knowledge-structures will be manipulated by giving participants pre-target information that is

more related to some concepts and less related to other concepts within the target passage, which deals with the topic of quantum physics[1]. This pre-target information is more related to concepts embedded in some paragraphs within the target passage and less related to concepts in other paragraphs (given the assumption that information in a paragraph is more related to other concepts within the same paragraph than it is to concepts contained in different paragraphs). Specifically, given that there are six paragraphs in the target passage that contain unique concepts[2], participants will be given pre-target information about concepts contained within three of these paragraphs, which will allow them to build knowledge structures more related to other concepts within these paragraphs, and less related to information in the remaining three paragraphs. Half of the participants in this study will be given such pre-target information concerning one set of three paragraphs (which I will call, for mnemonic ease, the "A paragraphs"), while the other half will be given pre-target information concerning a second set of three paragraphs (the "B paragraphs"), with these two paragraph sets being mutually exclusive. Given the predictions of the knowledge-schema theory outlined above, it is expected that the former group of participants will rate the A paragraphs as more interesting than the B paragraphs, since for these participants the A paragraphs should induce more schema enhancement, whereas the latter participants will judge the B paragraphs as more interesting than the A paragraphs, since for these participants the B paragraphs should induce more schema enhancement.

Testing the second hypothesis of the knowledge-schema theory will involve looking at the relation between learning from the target passage and interest for this passage regardless of the

[1] This topic was chosen as the subject of the target passage due to the expectation that participants will have minimal pre-experimental knowledge about quantum physics, so that the information received in the pre-target phase participants receive will effectively determine their prior knowledge.

[2] The seventh (final) paragraph of the target passage is of a summary nature, and as such does not contain any unique concepts.

content of the pre-target information received. Across all conditions, the KST predicts that participants who learn more from the target passage, as measured by improvement on a memory test, will rate this passage as more interesting than those who learn less.

Method

Participants

Sixty-three undergraduates (37 women and 26 men) in an introductory psychology course at the University of California, Los Angeles, participated in this experiment to receive course credit.

Design

A two-factor mixed design was used in this study. The manipulated between-participants factor was the relation of the pre-target passage information each participant received to concepts embedded in particular paragraphs within the target passage. There were two levels of this condition: some participants received pre-target passage information taken from paragraphs 1, 5, and 6 of the target passage, and others received pre-target passage information taken from paragraphs 2, 3, and 4 of the target passage. For mnemonic ease, the former group of participants will be referred to as "group A" and the latter as "group B."

The within-participants factor was the set to which paragraphs in the target passage belong in relation to the pre-target information. Paragraphs 1, 5, and 6, about which participants in group A receive prior information, will be referred to as the "A paragraphs," and paragraphs 2, 3, and 4, about which participants in group B receive prior information, will be referred to as "B paragraphs." The two sets of paragraphs were chosen based on the paragraph interest ratings for this passage collected from participants in a previous experiment (Yarlas, 1998). In order to reduce the variance in interest ratings due to paragraph effects, all possible configurations of paragraph sets were examined. The two sets chosen in the current experiment yielded the

smallest difference in interest ratings across all conditions in the previous experiment, with the A paragraphs having a mean interest rating of 4.00 (SD = 1.84), and the B paragraphs having a mean interest rating of 4.04 (SD = 1.77).

In addition to the two factors, four variables predicted to have effects on either interest or learning were measured and entered into the analyses as covariates. These variables are participant gender, individual interest for physics, individual interest for quantum physics, and pre-experimental knowledge of physics.

A number of dependent variables of theoretical interest were measured. Interest ratings for each paragraph in the target passage, as well as a global passage interest rating, were measured. These ratings will be utilized in two ways in the analysis. First, a composite of the paragraph ratings within each set will be computed (i.e., an average of the interest ratings for each of three paragraphs within each set) to allow for a comparison due to this factor. Second, a composite of paragraph and global passage interest ratings will be computed into a single scale that will represent overall interest for the target passage. The amount of learning induced by the target passage will also be measured so that the relation between learning and overall passage interest can be assessed.

Materials

Individual interest measures. Participants were given two questions designed to measure their individual interest for general physics and quantum physics. The first question asked "How interested are you in physics on a scale of 1 to 10?" while the second question asked "How interested are you in quantum physics (the study of subatomic particles) on a scale of 1 to 10?" Below each question was an anchoring scale indicating that higher numbers indicated a higher degree of interest.

General knowledge test of physics. A twenty-five item multiple-choice test was used to assess participants' general knowledge of physics. The 25 questions probed participants' knowledge for various subdomains within physics, including astronomy, Newtonian laws, and quantum physics. This test has been used and shown to be a reliable measure of general physics knowledge in past research (Alexander, Kulikowich, & Schulze, 1994; Garner & Gillingham, 1991).

Domain knowledge test of quantum physics. This measure consisted of 12 multiple-choice questions designed to assess participants' knowledge about quantum physics concepts contained in the target passage. The test was developed by identifying concepts contained within the target passage, and then creating questions concerning 12 of those concepts. The 12 questions in the domain knowledge test corresponded to 12 concepts contained within the first six paragraphs of the target passage, such that two questions probed for information from each of these six paragraphs. A sample question from the domain knowledge test, with (c) as the correct answer, is:

> A key assumption of the standard model is that:
> (a) there are twice as many quarks as leptons in any particle configuration
> (b) only some types of quarks pair with leptons
> (c) there is a symmetrical relationship between the pairing of quarks and leptons
> (d) all types of quarks pair with all types of leptons
> (e) any type of lepton can symmetrically pair with any other type of lepton

The questions used in the domain knowledge test are presented in Appendix A.

All participants were presented with the domain knowledge test three times. The first time this test was presented was near the beginning of the experiment to measure pre-experimental (baseline) domain knowledge. The second time this test was presented occurred after participants read the pre-target information, and the third time occurred after participants had

read the target passage. The questions were randomly ordered across participants for each of the three instances. The degree of improvement on this test due to reading the target passage (i.e., the number of questions answered correctly on the second domain knowledge test subtracted from the number of questions answered correctly on the third domain knowledge test) served as the measure of learning used in the statistical analyses, as this improvement is indicative of the amount of increased knowledge directly attributable to the target passage.

Pre-target information

The experimental manipulation in this experiment occurred as a function of the type of pre-target information a participant received. Pre-target information varied on the paragraph set from which the concepts presented were taken. Participants assigned to group A were given information about one of the concepts embedded in each of the three A paragraphs of the target passage, while participants assigned to group B were given information regarding one of the concepts embedded in each of the three B paragraphs of the target passage. All participants, then, received pre-target information about a total of three concepts taken from the target passage.

Within each group, the concepts taken from the target passage paragraph sets were counterbalanced to control for effects due to the specific concepts used. Two concepts were identified from each of the six paragraphs of the target passage (corresponding to the concepts tested by the 12 questions in the domain knowledge test). Half of the participants in each condition received pre-target information corresponding to one-half (three) of these concepts, while the other half of participants received pre-target information corresponding to the other half (three) of these concepts. The pairing of these concepts for each condition were determined randomly, with the constraint that only one concept was taken from each paragraph. In sum, four

different pre-target information passages were used, such that half of the participants in group A received information regarding three (of six) concepts presented in the A paragraphs of the target passage, while the other half received information concerning the other three concepts presented in the A paragraphs, and the same for group B. The four pre-target information passages used in this experiment are presented in Appendix B.

Target passage

The target passage used in this experiment was a modification of an article in the magazine Discover (Trefil, 1989) about quarks, leptons, and the search for a standard model of quantum physics. This modification was performed by Alexander, Kulikowich, & Schulze (1994); the general tone and coherence of the modified passage reflect that of the original article. This passage was chosen due to the low amounts of initial knowledge about these concepts demonstrated by the participants in Alexander, Kulikowich, & Schulze's study, indicating that participants would have approximately the same, low amount of pre-experimental knowledge about the topic of the target passage. The target passage consisted of seven paragraphs, with a total of 857 words. This passage is presented in Appendix C.

At the bottom right-hand side of each of the seven paragraphs were the words "Interest rating" with a blank line next to it, for which participants were instructed to write in a number between 1 and 10 reflecting how interesting they judged the preceding paragraph (with higher numbers indicating higher interest). After the last paragraph, participants were asked to rate (also on a scale of 1 to 10) how interesting they found the passage as a whole, and to verbally describe why they found the passage at that level of interest, as well as any effect reading the pre-target information had on their interest for the target passage. From the seven paragraph ratings and the global passage rating, a composite interest score was computed by averaging the interest ratings

for all 7 paragraphs, then averaging that mean with the passage interest rating. Thus, the interest ratings for the seven paragraphs contributed one-half of the composite interest score, while the interest rating of the passage as a whole contributed the other half of this score[3].

Procedure

Participants received a packet appropriate to their randomly assigned condition and counterbalance, containing the materials described above. The cover page of the packet told participants that the packet contained some questions to answer and some passages to read. Participants were instructed to answer all questions as accurately and honestly as possible, and to let the experimenter know if they had any questions.

On the second page of the packet were the two individual interest scales, one for general physics and one for quantum physics. The next section of the packet consisted of the 25-item general knowledge test of physics. Following the general knowledge test was a section containing the first 12-question domain knowledge test of quantum physics. For both of these tests, participants were instructed to circle the letter of the answer they thought best answered each question.

Participants were then presented with the pre-target information passage with instructions to read the passage carefully. The domain knowledge test of quantum physics was given a second time, with additional instructions not to turn back to the previous pages when answering the questions.

Next, participants were presented with the target passage. They were instructed to read the passage carefully, and to rate each paragraph upon its completion for interest on a scale of 1 to

[3]Participants' average paragraph ratings and global passage rating were highly correlated, $r = .93$. In addition, all analyses of interest using either the average paragraph ratings or the global passage rating as the dependent variable yielded the same pattern of results as the analyses using the composite interest score.

10, with higher scores indicating higher interest. Upon completion of the passage, participants were instructed to indicate (also on a scale of 1 to 10) their interest for the passage as a whole, and to explain their reasons for this rating, as well as to indicate any effect due to reading the pre-target information on this rating and the individual paragraph ratings.

Finally, participants were given the domain knowledge test of quantum physics a third time, again with the instructions not to turn back to other sections of the packet when answering the questions. After completing this test, participants were debriefed and their packets were collected.

Expected results

The first critical prediction is that performance on particular items on the final domain knowledge test will vary as a function of the relation between the concept tested and a participant's pre-existing schemas. Schema enhancement is predicted to be greater for concepts more closely related to these schemas, which are built by the pre-target information, than for concepts less related to these schemas. Therefore, it is expected that participants will perform better on questions that test concepts that are either presented in the pre-target information passage, or are within the same paragraph set from which these concepts were chosen, than for questions that test concepts taken from the other paragraph set.

The second critical prediction is that there should be a crossover interaction between condition and paragraph set on interest ratings. Given the predictions of the knowledge-schema theory of cognitive interest that schema enhancement predicts interest for information, and the prediction that concepts more closely related to one's knowledge structures is more likely to induce schema enhancement than less related concepts, it is expected that participants will rate the paragraphs in the target passage from which the concepts were taken for in the pre-target

information passage as more interesting than the paragraphs from which they received no initial information. More simply put, it is predicted that participants in group A will rate the A paragraphs as more interesting than the B paragraphs, and that participants in group B will rate the B paragraphs as more interesting than the A paragraphs.

The third critical prediction, that learning predicts interest, will be examined by assessing the relation between learning and overall passage interest independent of the manipulation. A correlational analysis will be used to test the strength of the covariation between these two measures, and a regression analysis will be used to test whether learning uniquely predicts interest when interest is regressed across learning, individual interest, general physics knowledge, and gender.

Results

Descriptive statistics

Scores on individual interest measures (on scales of 1 to 10) indicate that participants were moderately interested in general physics ($\underline{M} = 4.17$, $\underline{SD} = 1.96$) but less interested in quantum physics ($\underline{M} = 3.24$, $\underline{SD} = 2.12$). On the general knowledge test of physics, participants correctly answered a mean of 16.10 ($\underline{SD} = 3.50$) out of 25 questions on this test.

Domain knowledge test of quantum physics

A two-factor ANCOVA, with the factors being condition and time of test, was conducted to examine differences on the number of correct answers on the three domain knowledge tests. A significant main effect was found as a function of time of test, $\underline{F}(2, 122) = 261.14$, $\underline{MSE} = 2.25$, $\underline{p} < .001$, while the interaction between condition and time of test ($\underline{F}(2, 122) = .25$, $\underline{MSE} = 2.25$, $\underline{p} > .7$) and the main effect due to condition ($\underline{F}(1, 57) = 1.65$, $\underline{MSE} = 3.97$, $\underline{p} > .2$) were not significant.

Planned comparisons were used to identify the specific differences between scores at each time of the domain knowledge test. Given the novelty and complexity of the subject matter (quantum physics), it was expected that participants would demonstrate low knowledge on the first domain knowledge test. Indeed, participants averaged only 2.94 (SD = 1.47) correct answers on this test. Scores on the second domain knowledge test across both conditions increased significantly from the first test, to a mean of 4.62 (SD = 1.44), $t(62) = 8.54$, $p < .001$. Thus, across participants, the pre-target information induced some learning. Scores on the final domain knowledge test (M = 8.68, SD = 2.28) also showed significant improvement from the second test, $t(62) = 16.57$, $p < .001$, indicating that the target passage induced a significant amount of learning across conditions.

Schema enhancement as a function of relation between pre-target information and paragraph set

To test the prediction that concepts more closely related to a pre-existing schema induces greater learning (through schema enhancement) than concepts less related to a pre-existing schema, correct answers on the final domain knowledge test as a function of condition and paragraph set were analyzed.

There are three categories of relations between the pre-target information and questions within each condition: same questions, which probe for information given to the participant in the pre-target information; more related questions, which probe for information not given in the pre-target information but taken from the same paragraph set; and less related questions, which probe for information not given in the pre-target information and taken from a different paragraph set.

A two-factor mixed-design ANCOVA was used to assess whether condition and relation of questions to pre-target information had an effect on the questions answered correctly on the third domain knowledge test. A significant main effect of relation was observed, $F(2, 122) = 10.40$,

MSE = .40, $p < .001$, while neither the main effect of condition, $F(1, 57) = 1.97$, MSE = .87, $p > .1$, nor the interaction, $F(2, 122) = 0.77$, MSE = .40, $p > .4$, were significant. Planned comparisons among the three types of relations revealed that across participants, same questions ($M = 2.49$, $SD = 0.76$) were more frequently answered correctly than were more related questions ($M = 2.22$, $SD = 0.83$), $t(62) = 2.33$, $p < .05$, or less related questions ($M = 1.97$, $SD = 0.76$)[4], $t(62) = 4.70$, $p < .001$. The critical comparison, between more related and less related questions, yielded that the more related questions were answered correctly more often than were the less related questions, $t(62) = 2.20$, $p < .05$. These results support the prediction that concepts more related to existing schema lead to greater schema enhancement (as indicated by a higher number correct on the final domain knowledge test) than concepts less related to existing schemas.

Analysis of interest as a function of condition and paragraph set

Given the findings above, it is predicted by the knowledge-schema theory that participants in group A will rate the A paragraphs as more interesting, while participants in group B will rate the B paragraphs as more interesting. A two-factor mixed design ANCOVA, with the two factors being condition and paragraph set and the dependent variable being paragraph interest ratings, was used to test this prediction. As predicted, a significant interaction between condition and paragraph set on interest ratings was observed, $F(1, 61) = 13.22$, MSE = .35, $p < .001$, while neither condition, $F(1, 57) = 0.85$, MSE = 5.59, $p > .3$, nor paragraph set, $F(1, 61) = 3.46$, MSE = .35, $p > .05$, exerted a main effect on interest ratings.

Planned comparisons were used to examine differences in interest ratings both within-participants (between paragraph sets for both groups) and between-participants (between conditions for both paragraph sets). For participants in group A, there was a slight, but not

[4]This is the mean and standard deviation of the average between the two sets of unrelated questions (e.g., for a

significant difference between interest ratings for the A paragraphs (M = 4.57, SD = 2.12) and interest ratings for the B paragraphs (M = 4.39, SD = 1.86), $t(31) = 1.62$, $p > .1$. Participants in group B, however, rated the B paragraphs (M = 4.68, SD = 1.92) as significantly more interesting than the A paragraphs (M = 4.10, SD = 1.80), $t(30) = 3.26$, $p < .01$. Across conditions, no significant differences were found: interest ratings of the A paragraphs were equivalent for participants in group A and group B, $t(61) = 0.96$, $p > .3$, and interest ratings for the B paragraphs were also equivalent for participants in group A and group B, $t(61) = 0.61$, $p > .5$. Although only one of the planned comparisons yielded a significant difference, it should be noted that all differences are in the predicted direction. Figure 1 provides a graphical presentation of these cell means.

Covariation between learning and interest

The knowledge-schema theory predicts that the degree of learning induced by the target passage should positively covary with interest for the passage. That is, regardless of condition and paragraph set, participants who learned more from the target passage should have higher judgments of interest than those who learned less. Consistent with this prediction, a correlational analysis of learning and interest yielded a positive correlation between the two measures, $r = .53$, $p < .001$.

Multiple regression analysis for interest

A regression analysis was conducted to determine the degree to which the four covariates (individual interest for physics and quantum physics, pre-experimental general physics knowledge, and gender) and learning predicted a unique amount of the variance in interest ratings. Interest ratings of the target passage were regressed across these five variables. As a

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participant in group A, the average number of B1 and B2 questions answered correctly).

group, these factors explained a significant amount of variance in interest judgments ($R^2 = .45$; $F(5,57) = 9.19$, $p < .001$). Of the five measures, only learning from the target passage predicted interest ratings significantly ($\beta = .449$; $t = 4.32$, $p < .001$). Thus, only learning reliably accounted for a unique amount of variance in interest judgments.

Discussion

Three critical predictions were tested in this experiment. The first two predictions were causally connected: that concepts more closely related to existing knowledge would lead to a higher degree of schema enhancement than concepts less related to knowledge, and that, as hypothesized by the knowledge-schema theory, information that leads to a greater amount of schema enhancement will be considered more interesting than information that leads to a lesser amount of schema enhancement. In order to examine this causal chain, the current study tested both of these predictions.

The first prediction, that schema enhancement is a direct function of relatedness between incoming information and a pre-existing knowledge structure, was supported by the data. Participants demonstrated significantly greater learning for concepts within the target passage that were more related to their knowledge-schema (as formed by the pre-target information) than for concepts that were less related to this schema. This finding allowed for a clear test of the second prediction.

The second prediction, held by the knowledge-schema theory, is that interest for information is a direct function of the amount of schema enhancement it induces. The data also supported this hypothesis: participants generally judged the paragraphs of the target passage that had led to greater schema enhancement as more interesting than the paragraphs that induced less schema

enhancement. This experiment, then, lends further support to the KST, that schema elaboration is a predictor of interest for informational.

The third critical prediction of this study was that, regardless of condition or paragraph set, the amount of learning induced by the target passage would predict the degree to which a participant judged the passage as interesting. This prediction was also supported by the data. A reliable correlation between learning from and interest for the target passage was observed, and a multiple regression analysis on interest ratings confirmed that this shared variance was largely unique, not accounted for by other seemingly relevant factors. The findings of the current research thus provide further evidence supporting the claims of the knowledge-schema theory regarding the causes of cognitive interest

The knowledge-schema theory of cognitive interest makes two meaningful contributions to the field of interest research. First, it integrates previously disparate work regarding the causes of interest. The KST accounts for numerous findings from past interest research, across both various classes of phenomena and various classes of informational environments, by identifying a shared construct underlying previous notions of interest. In identifying a single construct to explain the causes of cognitive interest, the KST introduces parsimony to a field that has to this point lacked a coherent framework. Second, the knowledge-schema theory makes clear, testable predictions about when interest should and should not occur across virtually any class of informational environment. The KST provides interest researchers with a model makes novel predictions about cognitive interest across many situations, and thus can be used as a starting point to inform future exploration into the question of how to maximize learning and interest.

Future research directions

The knowledge-schema theory is in a formative stage, and as such needs a good deal of further refinement and specificity. The plans for future research described below will help to improve the usefulness and applicability of the KST.

At this time, the knowledge-schema theory makes only qualitative predictions regarding interest as function of schema enhancement and modification: when these processes occur, the environment will be judged as interesting; when they do not occur, the environment will be judged as uninteresting. However, it is too simplistic to expect that the phenomenon is purely qualitative; rather, it is more likely the case that varying degrees of schema enhancement and schema modification produce varying amounts of interest. It is possible that interest occurs monotonically as a result of these processes, such that interest continually increases as the amount of schema enhancement or modification increases. Alternatively, it may be that interest instead follows an inverted-U shaped function of schema elaboration or change, such that too little or too much enhancement or change might not lead to high interest, but some moderate amount of enhancement or change might lead to optimal interest for an environment. For example, too much schema enhancement might sacrifice parsimony among concepts in one's knowledge representations, or too much schema modification may cause anxiety in person by causing them to doubt the veracity of core concepts in their belief system, and thus reduce interest. Future experiments will identify quantitative differences in schema enhancement and modification and examine the degree of interest they produce.

Another line of work that will help increase the predictiveness of the knowledge-schema theory is the identification of relevant cognitive variables that uniquely explain variance in interest judgments. One such variable is "need for cognition," which was defined by Cacioppo & Petty (1982) as "the tendency for an individual to engage in and enjoy thinking" (p. 116; see

Cacioppo, Petty, Feinstein, & Jarvis, 1996 for a review). Durso and Crutchfield (1997) found that need for cognition influenced interest ratings for textual passages. It is possible that need for cognition moderates the relation between schema enhancement or modification and interest; it seems plausible that individuals who seek intellectual stimulation will find information that meaningfully increases or changes their knowledge more interesting than those who do not. Future studies of the KST should test this hypothesis by measuring need for cognition and other related individual difference variables and assessing their influence on interest ratings.

On a related point, participants in the experiment presented here were all students at a highly competitive university, and as such are likely to have a generally greater level of need for cognition than a sample that would be chosen from the general population. Different sample populations should therefore be used in future studies of the KST to increase the variance in need for cognition among participants.

Future studies of the knowledge-schema theory should also examine learning and interest across various types of informational environments. The current experiment measured learning and interest for textual passages only; however, the KST should predict interest for information presented in a variety of ways, such as lectures, multimedia presentations, and problem-solving tasks. Future experiments testing the KST should thus study the relation between learning and interest for non-textual information environments.

All tests of the knowledge-schema theory to this point have measured interest by self-report, with indicating their interest for information by ratings on Likert-type scales. To increase the utility of the KST, it is also important to show that learning predicts behavioral manifestations of interest. Cognitive curiosity (Malone, 1981; Malone & Lepper, 1987) appears to be a behavioral indicator of cognitive interest; as such, the KST predicts that learners will seek out information

that leads to schema enhancement or modification. One way to test this hypothesis is to examine information-seeking behavior in an exploratory learning environment, such as hypertext, in which learners are able to choose the information they will receive. An analysis of the type of information people choose to receive given limited cognitive resources, and how this information aids in constructing, enhancing, and modifying their knowledge will further inform us of the nature of the relation among knowledge, learning, and interest.

Educational implications of the knowledge-schema theory of cognitive interest

The goal of the current research is to better understand the cognitive causes of interest for information that stem from the relation between the structure and content of an informational environment and a person's state of knowledge. It is hoped that the development of a predictive model of cognitive interest can be applied to formal learning environments to optimize motivation and learning from instruction. It is well established that students find much of their classwork boring (e.g., Csikszentmihalyi & Larson, 1984; Papert, 1989; Sarason, 1983). Attempts to increase student interest in the concepts they are learning in the classroom will improve both their intrinsic motivation to learn the material as well as increase the quantity and quality of this learning.

A major implication of the knowledge-schema theory for classroom learning is the importance of assessing student knowledge. Other researchers (e.g., Baxter, Elder, & Glaser, 1996; Marshall, 1993; Naveh-Benjamin, McKeachie, & Lin, 1989; Perkins, 1992) have pointed out the significance of knowing what a learner knows in order to maximize their future learning. The KST adds to this evidence, for it shows that knowledge assessment is crucial for maximizing both learning and interest. To use a metaphorical example, a learner's prior knowledge and the current informational environment can be thought of as pieces of a puzzle. Just as only certain

pieces in a puzzle fit together well, only certain information "fits well" with a person's knowledge-schemas: information that induces schema elaboration or modification, and thus interest. In order to know what are the best pieces of information to add to a person's knowledge, it is necessary to know the shape of the knowledge piece; that is, the structure of the learner's knowledge representations. Probing the state of the learner's knowledge allows one to structure the incoming information in ways that lead to a good fit, optimizing learning and therefore interest.

The primary application of the knowledge-schema theory to educational settings is using the theory as a guide to create instructional environments that teach concepts in ways that maximize interest. This would involve assessing a learner's current state of knowledge within a domain, and then creating materials that optimize the degree to which the learner's knowledge-schemas are enhanced and modified. It is expected that these instructional materials would produce more learning and interest than materials in current use that present these concepts in ways that are not guided by the KST. This approach to instruction can be applied to any number of methods for presenting concepts in the classroom, including textual materials, lectures, problem sets, multimedia presentations, and educational software packages.

The study presented here provides further evidence supporting the central hypotheses of the knowledge-schema theory of cognitive interest: that learning, as mediated by schema enhancement and schema modification, increases interest for information. Past research on interest, as mentioned earlier, has shown that increased interest for information leads to increases in learning. Combining these two lines of findings yields what can be thought of as an ever-increasing spiral of learning and interest: presenting concepts in ways that optimizes learning leads to enhanced interest, which leads to more learning, which leads to more interest, and so on.

The knowledge-schema theory of cognitive interest, then, provides some guidance to achieving the goal of maximal interest and learning in the classroom.

References

Alexander, P. A., & Jetton, T. L. (1996). The role of importance and interest in the processing of text. Educational Psychology Review, 8, 89 - 121.

Alexander, P. A., Kulikowich, J. M., & Jetton, T. L. (1994). The role of subject-matter knowledge and interest in the processing of linear and nonlinear texts. Review of Educational Research, 64, 201-252.

Alexander, P. A., Kulikowich, J. M., & Schulze, S. K. (1994). How subject-matter knowledge affects recall and interest. American Educational Research Journal, 31, 313-337.

Arnold, F. (1910). Attention and interest: A study in psychology and education. New York: Macmillan.

Bartlett, F. C. (1932). Remembering: A study in experimental and social psychology. New York: Cambridge University Press.

Baxter, G. P., Elder, A. D., & Glaser, R. (1996). Knowledge-based cognition and performance assessment in the science classroom. Educational Psychologist, 31, 133-140.

Bentler, P. M. (1990). Comparative fit indices in structural models. Psychological Bulletin, 107, 238-246.

Berlyne, D. E. (1960). Conflict, Arousal, and Curiosity. New York: McGraw-Hill.

Berlyne, D. E. (1971). Aesthetics and psychobiology. New York: Appleton-Century-Crofts.

Berlyne, D. E. (1974). Studies in the new experimental aesthetics: Steps toward an objective psychology of aesthetic appreciation. Washington, DC: Hemisphere Publishing Company.

Boggiano, A. K., Ruble, D. N., & Pittman, T. S. (1982). The mastery hypothesis and the overjustification effect. Social Cognition, 1, 38-49.

Boykin, W. (1977). Verbally expressed preference and problem-solving proficiency. Journal of Experimental Psychology: Human Perception and Performance, 3, 165-174.

Cacioppo, J. T., & Petty, R. E. (1982). The need for cognition. Journal of Personality and Social Psychology, 42, 116-131.

Cacioppo, J. T., Petty, R. E., Feinstein, J. A., & Jarvis, W. B. G. (1996). Dispositional differences in cognitive motivation: The life and times of individuals varying in need for cognition. Psychological Bulletin, 119, 197-253.

Csikszentmihalyi, M. (1975). Beyond boredom and anxiety. San Francisco : Jossey-Bass.

Csikszentmihalyi, M. (1990). Flow : The psychology of optimal experience. New York: Harper & Row.

Csikszentmihalyi, M., & Larson, R. (1984). Being adolescent. New York: Basic Books.

Danner, F. W., & Lonky, E. (1981). A cognitive-developmental approach to the effects of rewards on intrinsic motivation. Child Development, 52, 1043-1052.

Day, H. I. (1965). Exploratory behavior as a function of individual differences and level of arousal. Unpublished doctoral dissertation, University of Toronto.

Day, H. I. (1967). Evaluations of subjective complexity, pleasingness and interestingness for a series of random polygons varying in complexity. Perception and Psychophysics, 2, 281-286.

Day, H. I. (1968). The importance of symmetry and complexity in the evaluation of complexity, interest, and pleasingness. Psychonomic Science, 10, 339-340.

De Garmo, C. (1902). Interest in education: The doctrine of interest and its concrete application. New York: Macmillan.

Dewey, J. (1913). Interest and effort in education. Cambridge: Houghton-Mifflin.

Durso, F. T., & Crutchfield, J. M. (1997, November). That's interesting: Knowledge, learning, and need for cognition. Paper presented at the Annual Meeting of the Psychonomic Society, Philadelphia, PA.

Frick, R. W. (1992). Interestingness. British Journal of Psychology, 83, 113-128.

Garner, R., & Gillingham, M. G. (1992). Topic knowledge, cognitive interest, and text recall: A microanalysis. Journal of Experimental Education, 59, 310-319.

Glenberg, A. M, Wilkinson, A. C., & Epstein, W. (1982). The illusion of knowing: Failure in the self-assessment of comprehension. Memory and Cognition, 10, 597-602.

Harty, H., Samuel, K. V., & Beall, D. (1986). Exploring relationships among four science teaching-learning affective attributes of sixth grade students. Journal of Research in Science Teaching, 23, 51-60.

Hidi, S. (1990). Interest and its contribution as a mental resource for learning. Review of Educational Research, 60, 549-571.

Iran-Nejad, A. (1987). Cognitive and affective causes of interest and liking. Journal of Educational Psychology, 79, 120-130.

Kintsch, W. (1980). Learning from text, levels of comprehension, or: Why anyone would read a story anyway. Poetics, 9, 87-98.

Krapp, A., Hidi, S., & Renninger, K. A. (1992). Interest, learning, and development. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), The role of interest in learning and development (pp. 3-26). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Malone, T. W. (1981). Toward a theory of intrinsically motivating instruction. Cognitive Science, 4, 333-369.

Malone, T. W., & Lepper, M. R. (1987). Making learning fun: A taxonomy of intrinsic motivations for learning. In R. E. Snow & M. J. Farr (Eds.), Aptitude, learning, and instruction: Volume 3. Conative and affective process analyses (pp. 223-253). Hillsdale, NJ: Erlbaum.

Mandler, G. (1982). The structure of value: Accounting for taste. In M. S. Clark & S. T. Fiske (Eds.) Affect and Cognition (pp. 3-36). Hillsdale, NJ: Erlbaum.

Marshall, S. P. (1993). Assessment of rational number understanding: A schema-based approach. In T. P. Carpenter, E. Fennema, & T. A. Romberg (Eds.), Rational numbers: An integration of research (pp. 261-288). Hillsdale, NJ: Lawrence Erlbaum Associates.

McMullin, P., & Steffen, J. (1982). Intrinsic motivation and performance standards. Social Behavior and Personality, 10, 47-56.

Naveh-Benjamin, M., McKeachie, W. J., & Lin, Y-G. (1989). Use of the ordered-tree technique to assess student's initial knowledge and conceptual learning. Teaching of Psychology, 16, 182-187.

Papert, S. (1980). Mindstorms: Children, computers, and powerful ideas. New York: Basic Books.

Pell, A. W. (1985). Enjoyment and attainment in secondary school physics. British Educational Research Journal, 11, 123-132.

Perkins, D. N. (1992). Smart schools: From training memories to educating minds. New York: Free Press.

Sarason, S. (1983). Schooling in America: Scapegoat and salvation. New York: Free Press.

Schank, R. C. (1979). Interestingness: Controlling inferences. Artificial Intelligence, 12, 273-297.

Shapira, Z. (1976). Expectancy determinants of intrinsically motivated behavior. Journal of Personality & Social Psychology, 34, 1235-1244.

Smail, B., & Kelly, A. (1984). Sex differences in science and technology among 11-yr-old schoolchildren: I. Cognitive. Research in Science & Technological Education, 2, 61-76.

Tamir, P., & Gardner, P. (1989). The structure of interest in high school biology. Research in Science & Technological Education, 7, 113-140.

Thorndike, E. L. (1935). Adult interests. New York: Macmillan.

Teigen, K. H. (1985a). The novel and the familiar sources of interest in verbal information. Current Psychological Research and Reviews, 4, 224-238.

Teigen, K. H. (1985b). Preference for news as a function of similarity. Scandinavian Journal of Psychology, 26, 348-356

Teigen, K. H. (1987). Intrinsic interest and the novelty-familiarity interaction. Scandinavian Journal of Psychology, 28, 199-210.

Trefil, J. (1989). The search for truth. Discover, 10, 56-61.

Wade, S. E., Buxton, W., & Kelly, M. (in press). Using think alouds to examine reader-text interest. Reading Research Quarterly.

Yarlas, A. S. (1998). Learning as a predictor of interest: The knowledge-schema theory of cognitive interest. Unpublished doctoral dissertation, University of California, Los Angeles.

Yarlas, A. S. (1999). Schema modification and enhancement as predictors of interest: A test of the knowledge-schema theory of cognitive interest. Manuscript under review.

Appendix A - Questions on Domain Knowledge Test

1. The standard model of quantum physics claims that:
   a. all subatomic particles have the same mass
   b. all subatomic particles are combinations of fundamental particles
   c. all subatomic particles have the same charge
   d. energy is proportionately equal to mass
   e. matter in the universe is constantly expanding

2. Transformation is:
   a. the process in which a quark becomes a lepton
   b. the process in which a lepton becomes a quark
   c. the process in which quarks and leptons merge to form a new particle
   d. the process in which energy is administered to create particle decay
   e. the process in which atoms bond to form molecules

3. Quarks are located:
   a. outside the nucleus of an atom
   b. at the point where atoms bond together
   c. at the point where elements bond together
   d. inside the nucleus of an atom
   e. in electrons

4. A key assumption of the standard model is that:
   a. there are twice as many quarks as leptons in any particle configuration
   b. only some types of quarks pair with leptons
   c. there is a symmetrical relationship between the pairing of quarks and leptons
   d. all types of quarks pair with all types of leptons
   e. any type of lepton can symmetrically pair with any other type of lepton

5. Which of the following statements is <u>true</u>:
   a. all leptons have mass
   b. all quarks have a positive charge
   c. no leptons have charge
   d. all quarks have mass, but some have no charge
   e. all quarks have mass and charge

6. One of the theorists who first proposed the standard model is:
   a. Max Planck
   b. Albert Einstein
   c. George Zweig
   d. Richard Feynman
   e. Stephen Hawking

7. Which of the following is <u>not</u> a type of quark:
   a. top
   b. bottom
   c. charm
   d. up
   e. under

8. Which of the following is <u>not</u> a type of lepton:
   a. tau
   b. gamma
   c. electron
   d. muon
   e. electron neutrino

9. Leptons are located:
   a. outside the nucleus of an atom
   b. at the point where atoms bond together
   c. at the point where elements bond together
   d. inside the nucleus of an atom
   e. in protons

10. The only equipment capable of observing the last quark is located at:
   a. Fermilab in Chicago
   b. California Institute of Technology (CalTech)
   c. Massachusetts Institute of Technology (MIT)
   d. Scripps Institute
   e. Max Planck Institute

11. Which of the following statements is <u>false</u>:
   a. all leptons have been confirmed
   b. leptons occur in pairs
   c. all leptons have mass
   d. there are 6 types of leptons
   e. some leptons have no charge

12. Which quark has not yet been found:
   a. top
   b. bottom
   c. charm
   d. up
   e. under

Appendix B - Pre-target information passages used in experiment 4

Group A (counterbalance 1)

According to the standard model of quantum physics, all matter is made up of two types of fundamental particles, quarks and leptons.

The standard model emphasizes symmetry between quarks and leptons. Until all quarks are found, this symmetry cannot be confirmed.

Confirming quarks and leptons is very difficult. Currently, only the Fermilab at Chicago has equipment powerful enough to detect the smallest of these particles.

Group A (counterbalance 2)

Physicists such as George Zweig have attempted to create a standard model of quantum physics.

Physicists have found five of the six quarks; the "top" quark has not yet been found.

Because they are so small, quarks cannot be directly detected. Instead they must be observed indirectly, by examining particles after a quark has decayed, called transformation which occurs when energy is imposed on an atom.

Group B (counterbalance 1)

Subatomic particles known as quarks have been found by physicists inside the nucleus of an atom.

The six quarks are called "top", "bottom," "strange," "charm," "up," and "down." The "top" and "bottom" quarks are also sometimes referred to as "truth" and "beauty."

Other particles, known as leptons, have also been found by physicists. Some leptons have mass, and other leptons do not.

Group B (counterbalance 2)

Subatomic particles known as leptons have been found by physicists revolving outside the nucleus of an atom.

Physicists have identified all six leptons. These six leptons are called "electron," "electron neutrino," "muon," "muon neutrino," "tau," and "tau neutrino."

Other particles, known as quarks, have also been found by physicists. All quarks have mass and charge.

Appendix C

Please read the following passage carefully. As you read, please indicate how interesting you think each paragraph is (on a scale of 1 to 10, with higher values indicating higher interest). Underline any sentences or phrases you find particularly interesting.

The 1960s were an era of elation and frustration in the world of physics. Particle accelerators had begun smashing the nuclei of atoms and physicists were discovering large numbers of particles. The technology was incredible, but the results were daunting. The number of particles emerging from the nuclei was huge and the relationships between the particles appeared quite complex. Something had to be simplified, and in 1964 Murray Gell-Mann and George Zweig, physicists at Caltech, independently proposed similar theories that would do just that. They believed that the "zoo" of particles was simply multiple arrangements of three fundamental particles. The particles were dubbed "quarks" after a line from James Joyce's novel Finnegan's Wake -- "Three quarks for Mister Mark!" The search for a comprehensive structure was on. -----> **Interest Rating ____ (from 1-10)**

The search was in fact a flurry of investigation that resulted in what is today known as the standard model. In this model, all matter is made up of two types of particles, called quarks and leptons. There are six quarks and six leptons, which combine to form everything that exists. Quarks are found in the nucleus of the atoms, while leptons swirl around the outside of the nucleus and link atoms together into molecules. This model has proven to be successful in test after test, and is the reigning theory of the fundamental structure of the universe. -----> **Interest Rating ____ (from 1-10)**

The model is also fairly complete. All six leptons have been confirmed, either by direct observation or with strong experimental evidence. It is well-accepted that the leptons occur in pairs, and that some have mass and some don't. For example, the electron (which has mass and charge) and the electron neutrino (which has neither mass nor charge) make up a pair. Similar pairs are made up of the muon and its massless, chargeless partner the muon neutrino, and the tau lepton and its massless, chargeless companion the tau neutrino. -----> **Interest Rating ____ (from 1-10)**

Quarks are also arranged in pairs, but all quarks have both mass and charge. The wry humor that appears in the origin of the name quark is also seen in the names of the individual quarks: "up" and "down" are the names of the particles forming one pair. The "strange" and "charm" quarks form another pair, and "truth" and "beauty" (or "top" and "bottom" to the less romantic) form the third pair. Scientists know that quarks are always confined to groups of two or three and have charges that are fractions of the smallest charge previously measured. For example, a proton, which has a charge of +1, is made up of two up quarks and one down quark. This is only possible if the up quarks have a charge of 2/3 and the down has a charge of -1/3. The proton, then, has a charge of 1 since 2/3 + 2/3 + -1/3 = 1. -----> **Interest Rating ____ (from 1-10)**

All the quarks have been confirmed in the laboratory, except the one known as truth (or top). Finding the truth quark is particularly important, since the heart of the standard model lies in the symmetry between quarks and leptons. The symmetry goes beyond the quark-quark and lepton-lepton pairs to "families" of two quarks and two leptons. Up and down quarks pair with electrons and electron neutrinos, strange and charm quarks pair with the muon and its neutrino, and truth (when found) and beauty quarks cozy up with the tau and its neutrino. If the truth quark is not found, the symmetry is not present and the entire model is discredited.
----->

Interest Rating ____
(from 1-10)

Symmetry has additional importance, though, since direct observation of quarks is not possible. As stated earlier, quarks are always bound in groups of two or three, and detection of individual quarks must be done by analyzing particles that contain quarks or the particles that are created when a quark decays (also called a transformation). This indirect observation is made especially difficult in the case of the truth quark because an enormous amount of energy is required to produce the transformation. Truth, according to the symmetry of the model, must have a large mass. This also means it must also have large energy according to Einstein's formula $E = mc^2$, which describes how mass and energy are really the same thing. This large expected mass means that observation of truth is practical at only one place on earth, the accelerator located at Fermilab, near Chicago. No other accelerator equipment is capable of producing high enough energy levels.
----->

Interest Rating ____
(from 1-10)

Most theoretical physicists expect that the truth quark will be found soon. In fact, most treat its discovery as a mere verification of a theory that they already accept as correct. If it isn't located, though, the standard model is wrong. The model could be "fixed up," but that would defeat the ultimate purpose of minimizing the number of fundamental particles. Not that this would be a crushing blow. Most physicists love the challenge of the unknown and are bored with the type of verification exercise that the current search for truth has become. The possibility that the theory could be wrong and that a brand new problem could present itself makes the search, or possible failure of that search, more tantalizing every day.
----->

Interest Rating ____
(from 1-10)

Questions

1. How interesting did you find the preceding **passage** as a whole on a scale of 1 to 10? ______
   (1 = extremely uninteresting, 5 = moderately interesting, 10 = extremely interesting)

Please describe why you found this passage to be at this level of interest. Describe any effect that the earlier short passage (in section IV) had on your interest for any particular paragraphs or the passage as a whole.

Author Note

This article is based on data collected for a doctoral dissertation submitted to the University of California, Los Angeles in partial fulfillment of the requirements for the doctorate degree. This research was supported by a National Science Foundation Graduate Research Fellowship and a UCLA Graduate Division Dissertation Year Fellowship, as well as small research grants from the UCLA Graduate Division and the UCLA Department of Psychology.

I wish to thank Keith Holyoak, Jim Stigler, Deborah Stipek, and especially Vladimir Sloutsky for their feedback on previous versions of this manuscript. I am especially indebted to my committee chairperson, Rochel Gelman, who provided invaluable assistance in conducting this research.

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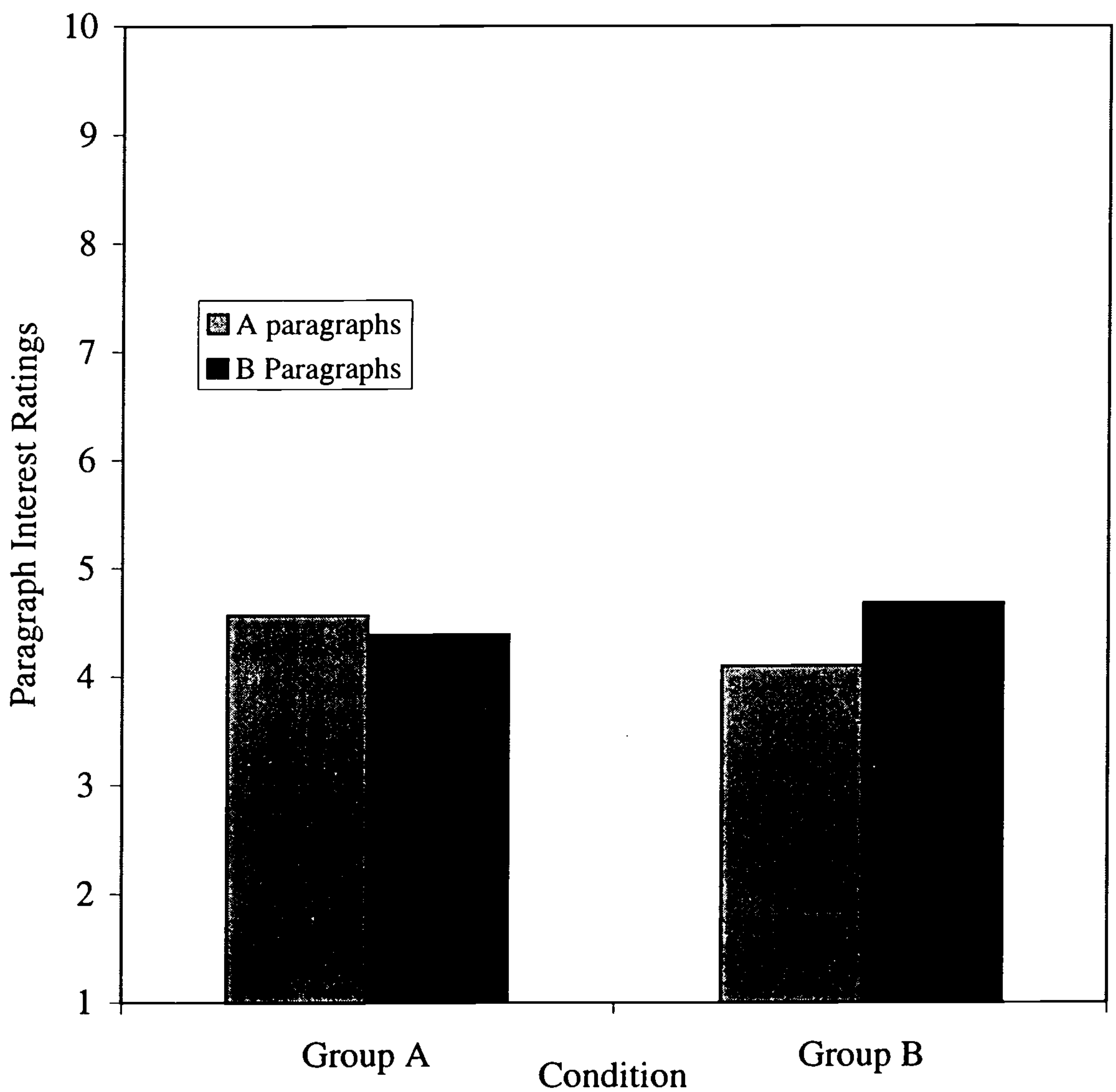
Figure 1. Paragraph interest ratings as a function of condition and paragraph set.



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